

WHAT IS CLAIMED IS:

1. A color image forming method using microcapsule toner which includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller  
5 microcapsule having a protective wall breakable with an ultrasonic wave of a corresponding predetermined resonant frequency, each smaller microcapsule containing inside its protective wall one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being  
10 disposed outside the protective wall, the method comprising the steps of:  
forming a toner image on an image carrier by applying the microcapsule toner to the image carrier in accordance with image information or forming a toner image pattern on the image carrier depending on the image information and then applying the microcapsule  
15 toner to the toner image pattern to thereby form a toner image;  
transferring the toner image, formed on the image carrier, directly or through an intermediate transfer medium to paper;  
irradiating the toner image applied to the image carrier with an ultrasonic wave of a predetermined resonant frequency corresponding to a  
20 color component item of the image information between the time when the toner image was formed on the image carrier and the time when the toner image was transferred to the paper such that the protective wall of a relevant one of the plurality of kinds of smaller microcapsules of the toner image is broken by the ultrasonic wave of the predetermined resonant  
25 frequency to thereby cause the two reacting substances to mix and react with each other to thereby color the toner image; and  
fixing the colored toner image to the paper whereby a color image

based upon the toner image is formed on the paper.

2. A color image forming method using microcapsule toner that includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller microcapsule having a protective wall breakable with an ultrasonic wave having a corresponding predetermined resonant frequency, each smaller microcapsule containing one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being disposed outside the protective wall thereof, the method comprising the steps of:

electrically charging the image carrier to a predetermined voltage level;

forming a static latent image of a voltage level pattern in accordance with image information on the image carrier charged in the charging step;

applying the microcapsule toner to the latent image formed on the image carrier to form a toner image;

irradiating the toner image formed on the image carrier with ultrasonic waves of a predetermined resonant frequency corresponding to a color component item of the image information to break the protective wall of a relevant one of the plurality of kinds of smaller microcapsules of the toner image such that the reacting substances mix and react with each other to thereby color the toner image;

transferring the colored toner image on the image carrier directly or through an intermediate medium to paper; and

fixing the transferred toner image to the paper whereby a colored

image based upon the colored toner is formed on the paper.

3. A color image forming method using microcapsule toner which includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller  
5 microcapsule having a protective wall breakable with an ultrasonic wave of a corresponding predetermined resonant frequency, each smaller microcapsule containing inside its protective wall one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being  
10 disposed outside the protective wall, the method comprising the steps of:  
electrically charging the image carrier to a predetermined voltage level;  
forming a static latent image of a voltage level pattern in accordance with image information on the image carrier charged in the  
15 charging step;  
applying the microcapsule toner to the latent image formed on the image carrier to thereby form a toner image;  
transferring the toner image formed on the image carrier in the applying step to an intermediate transfer medium;  
20 irradiating the toner image transferred to the with a predetermined resonant frequency corresponding to a color component item of the image information to break the protective wall of a relevant one of the plurality of kinds of smaller microcapsules of the toner image such that the reacting substances mix and react with each other to thereby color the toner image;  
25 transferring the colored toner directly or through an intermediate medium to paper; and  
fixing the transferred toner image to the paper whereby a color

image based upon the colored toner is formed on the paper.

4. A color image forming apparatus using microcapsule toner which includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller microcapsule having a protective wall breakable with an ultrasonic wave of a corresponding predetermined resonant frequency, each smaller microcapsule containing inside its protective wall one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being disposed outside the protective wall, the apparatus comprising:

toner image forming means for forming a toner image on an image carrier by applying the microcapsule toner to the image carrier in accordance with image information concerned or forming a toner image pattern depending on the image information and for applying the microcapsule toner to the toner image pattern to thereby form a toner image;

transfer means for transferring the toner image formed on the image carrier directly or through an intermediate transfer medium to paper;

coloring means for irradiating the toner image formed on the image carrier with an ultrasonic wave of a predetermined resonant frequency corresponding to a color component item of the image information between the time when the toner image was formed on the image carrier and the time when the toner image was transferred to the paper such that the protective wall of a relevant one of the plurality of kinds of smaller microcapsules of the toner image is broken by the

ultrasonic wave of a predetermined resonant frequency to cause the reacting substances to mix and react with each other to thereby color the toner image ; and

fixing means for fixing the colored toner image to the paper

5 whereby a color image based upon the toner image is formed on the paper.

5. The color image forming apparatus according to claim 4, wherein the toner image forming means comprises:

charging means for charging the image carrier to a predetermined  
10 voltage level;

static latent image forming means for forming a static latent image of a voltage level pattern in accordance with image information on the image carrier charged by the charging means; and

developing means for applying the microcapsule toner to the latent  
15 image formed on the image carrier.

6. The color image forming apparatus according to claim 5, wherein the coloring means is disposed at a position where it colors the toner image between the development by the developing means and the  
20 transfer of the toner image by the transferring means.

7. The color image forming apparatus according to claim 4, wherein the transferring means comprises intermediate transfer means for transferring the toner image on the image carrier to an intermediate  
25 transfer medium, and the coloring means is disposed at a position where it colors the toner image transferred to the intermediate transfer medium.

8. The color image forming apparatus according to claim 7, wherein the coloring means irradiates the toner image transferred to the intermediate transfer medium with an ultrasonic wave of a predetermined resonant frequency from the side of the toner image.

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9. The color image forming apparatus according to claim 8, wherein the coloring means irradiates the transferred toner image with the ultrasonic wave of the predetermined frequency through an ultrasonic transmission material of a liquid- or solid- phase material and not through  
10 a gas phase material.

10. The color image forming apparatus according to claim 4, wherein the coloring means comprises an ultrasonic line head.

15 11. The color image forming apparatus according to claim 10, wherein the ultrasonic line head comprises a multiplicity of ultrasonic elements arranged in a primary scan direction and supplied with ultrasonic output signals based upon image information from a plurality of individual applying electrodes to thereby irradiate the plurality of kinds of  
20 smaller microcapsules with ultrasonic waves of different resonant frequencies corresponding to the respective color component items of the image information.

12. The color image forming apparatus according to claim 11,  
25 wherein a focused width of the ultrasonic output from any particular one of the multiplicity of ultrasonic elements corresponds to that of one pixel.

13. The color image forming apparatus according to claim 12,  
wherein those of the plurality of ultrasonic elements disposed in any  
adjacent limited range of each side of the particular ultrasonic element  
produce respective ultrasonic waves so as to be focused at the same timing  
5 on the same position as the ultrasonic waves produced by the particular  
ultrasonic element are focused.

14. The color image forming apparatus according to claim 13,  
wherein the production of the respective ultrasonic waves so as to be  
10 focused at the same timing on the same position is performed by  
sequentially shifting the timing of outputting the ultrasonic waves based  
upon the distance between the focusing position and the each of the  
ultrasonic elements.

15 15. The color image forming apparatus according to claim 11,  
wherein the ultrasonic element comprises a piezoelectric element.

16. The color image forming apparatus according to claim 4,  
wherein the image information corresponding to the toner image formed by  
20 the toner image forming means comprises ORed items of image  
information about the respective colors, and the image information  
delivered to the coloring means comprises items of image information  
about the respective colors.

25 17. A color image forming apparatus comprising:  
converting means for converting video data to print data;  
OR operation means for performing an OR operation on items of

image information about respective colors contained in print data;

ultrasonic output signal producing means for producing an ultrasonic output signal of a resonant frequency based upon each item of the image information about the respective colors; and

5           coloring means for producing an ultrasonic wave in accordance with the ultrasonic output signal of the resonant frequency and for irradiating the microcapsule toner with the ultrasonic wave to color the microcapsule toner.

10           18.     The color image forming apparatus according to claim 17, wherein the microcapsule toner includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller microcapsule having a protective wall breakable with an ultrasonic wave of a corresponding predetermined  
15   resonant frequency, each smaller microcapsule containing inside its protective wall one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being disposed outside the protective wall such that the outer shell of a relevant one of the plurality of kinds of smaller  
20   microcapsules is broken with irradiation of the ultrasonic waves of the corresponding resonant frequency to thereby cause the reacting substances to diffuse and mix with each other to perform a coloring reaction.

            19.     The color image forming apparatus according to claim 17,  
25   wherein the ultrasonic output signal producing means produces a resonant frequency signal to produce the color of each of magenta, cyan, yellow and black.



20. The color image forming apparatus according to claim 17, wherein the ultrasonic output signal producing means produces no resonant frequency signal and hence prevents production of any color.

5 21. The color image forming apparatus according to claim 17, wherein the ultrasonic output signal producing means produces image information smaller in pixel number than the ORed data produced by the OR operation means, and delivers the produced image information to the coloring means.

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22. Microcapsule toner which includes a plurality of larger microcapsules each of which contains a plurality of kinds of smaller microcapsules dispersed therein, each smaller microcapsule having a protective wall breakable with an irradiating ultrasonic wave of a  
15 corresponding predetermined resonant frequency, each smaller microcapsule containing inside its protective wall one of two reacting substances that react with each other when mixed to thereby cause a coloring reaction and the other of the two reacting substances being disposed outside the protective wall such that the protective wall of a  
20 specified one of the plurality of kinds of smaller microcapsules is broken by irradiation of the ultrasonic waves of the corresponding predetermined resonant frequency to thereby cause the reacting substances to diffuse and mix with each other to produce a coloring reaction.

25 23. The microcapsule toner according to claim 22, wherein one of the reacting substances is a color former, and the other is a developer.

24. The microcapsule toner according to claim 22, wherein the other reacting substance is dispersed in a holding material contained within the larger microcapsule.

25. The microcapsule toner according to claim 22, wherein each  
5 of the plurality of kinds of smaller microcapsules contains at least two different ones of color formers of magenta, cyan, yellow and black.

26. The microcapsule toner according to claim 22, wherein the plurality of kinds of smaller microcapsules contains an air bubble.

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27. The microcapsule toner according to claim 22, wherein the plurality of kinds of smaller microcapsules is colorless and transparent before the coloring reaction occurs.

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28. The microcapsule toner according to claim 22, wherein the plurality of kinds of smaller microcapsules are different in at least one of outer diameter, shell thickness and material so as to be broken by ultrasonic waves of different resonant frequencies, respectively.

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29. The microcapsule toner according to claim 22, wherein  
when

the plurality of kinds of smaller microcapsules contained in each larger microcapsule produce four different colors a, b, c and d, a ratio in number Na: Nb: Nc: Nd of the smaller microcapsules that produce the respective  
25 four different colors a, b, c and d satisfies:

$$Na: Nb: Nc: Nd = r_4^3/r_1^3: r_4^3/r_2^3: r_4^3/r_3^3: 1$$

where a, b, c and d are the four kinds of colors to be produced by the plurality of kinds of smaller microcapsules contained in each larger microcapsule, and  $r_1, r_2, r_3$ , and  $r_4$  are the respective radii of the smaller  
5 microcapsules that produce the corresponding four kinds of colors and have a relationship  $r_1 \leq r_2 \leq r_3 \leq r_4$ .

30. The microcapsule toner according to claim 22, wherein the larger microcapsule is constructed so as to satisfy the following expression:  
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$$(q/0.4) \times Br^3/r_1^3 \leq Na \leq Hr^3/(r_1^3 \times 6.4)$$

where a, b, c and d are the four kinds of colors to be produced by the plurality of kinds of smaller microcapsules contained in each larger  
15 microcapsule,  $r_1, r_2, r_3$ , and  $r_4$  are the respective radii of the smaller microcapsules that produce the corresponding four kinds of colors a, b, c and d and have a relationship  $r_1 \leq r_2 \leq r_3 \leq r_4$ , q is a percent of a total volume of all the color formers occupied in a whole volume of the larger microcapsule, 2Br and 2Hr are the outer and inner diameters, respectively,  
20 of the larger microcapsule, and Na is the number of smaller microcapsules of the minimum radius  $r_1$ .

31. The microcapsule toner according to claim 22, wherein the number of colors to be produced by the plurality of kinds of smaller  
25 microcapsules is four, and each of the smaller microcapsules that produce the four different colors has a grain size with a common error.